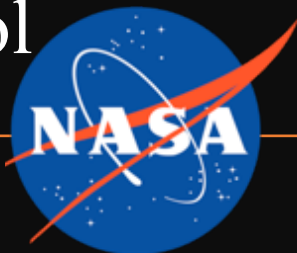


Gigantic Dust Intrusion into the Caribbean Basin and Southern U.S. in June 2020: Satellite and Model Perspectives

Hongbin Yu, NASA Goddard Space Flight Center

Qian Tan, Lillian Zhou, Yaping Zhou, Huisheng Bian, Mian Chin, Dongchul Kim, Robert Levy, Yingxi Shi, Lorraine Remer, Qianqian Song, Zhibo Zhang, Yaswant Pradhan, Claire Ryder, Olga Mayol



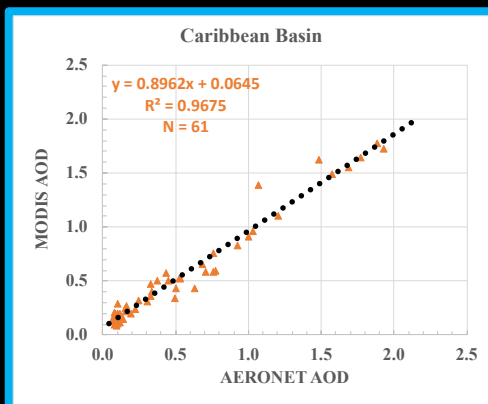
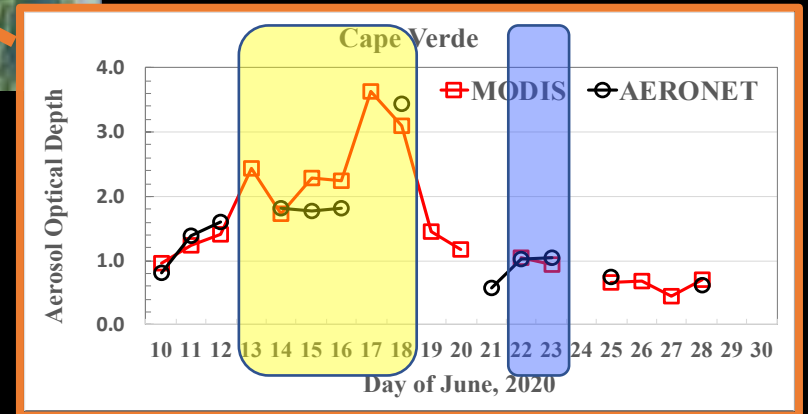
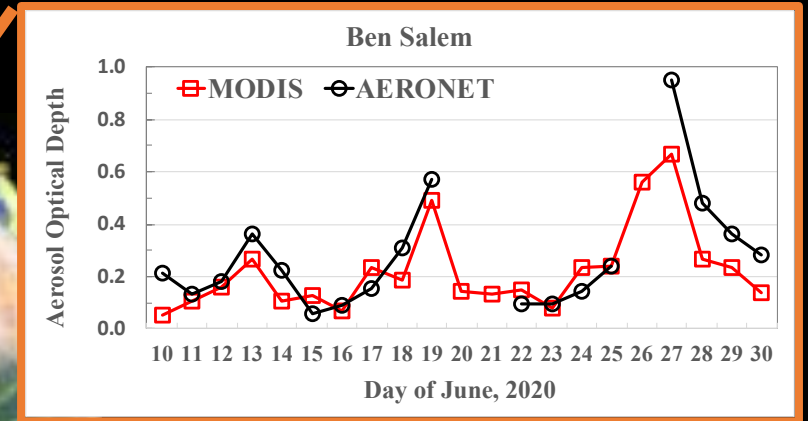
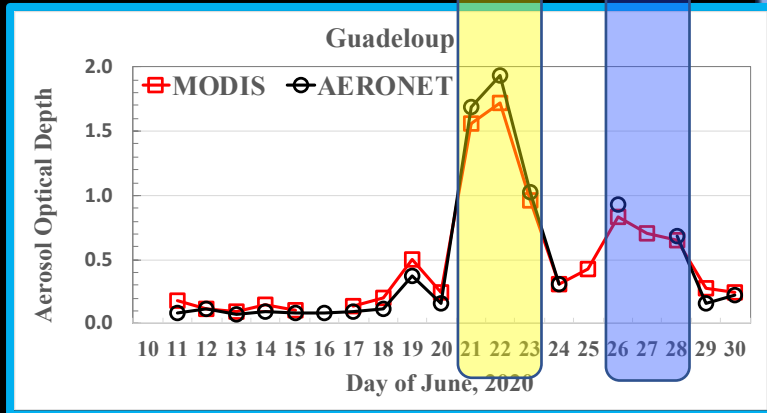
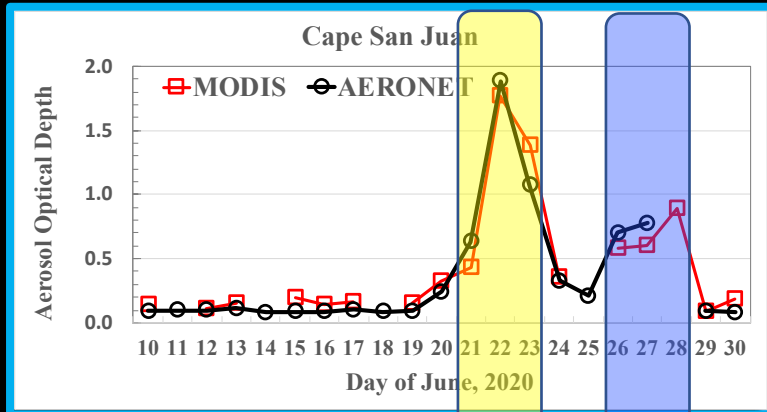
A panorama of dual dust clouds snapped by EPIC/DSCOVR from 1 million miles above at 14:47:32 GMT on 6/23/2020



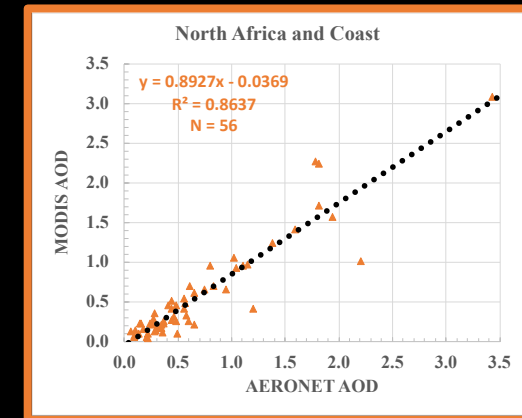
<https://epic.gsfc.nasa.gov/>



MODIS vs. AERONET

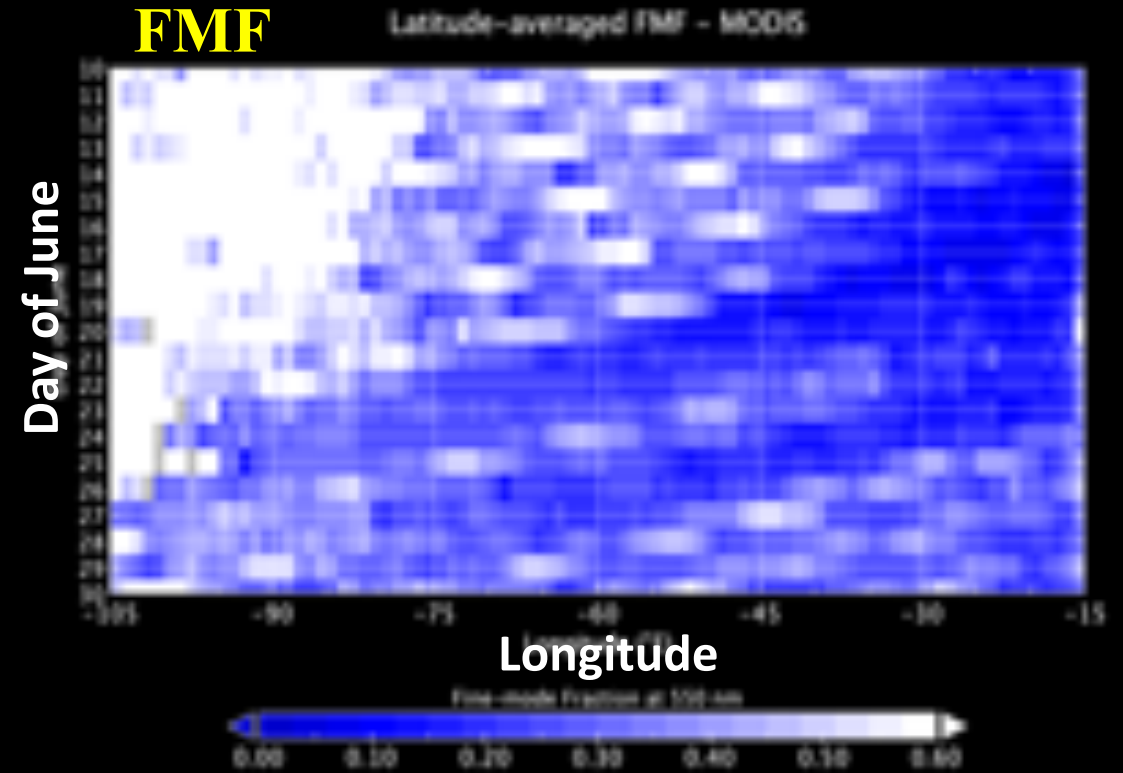
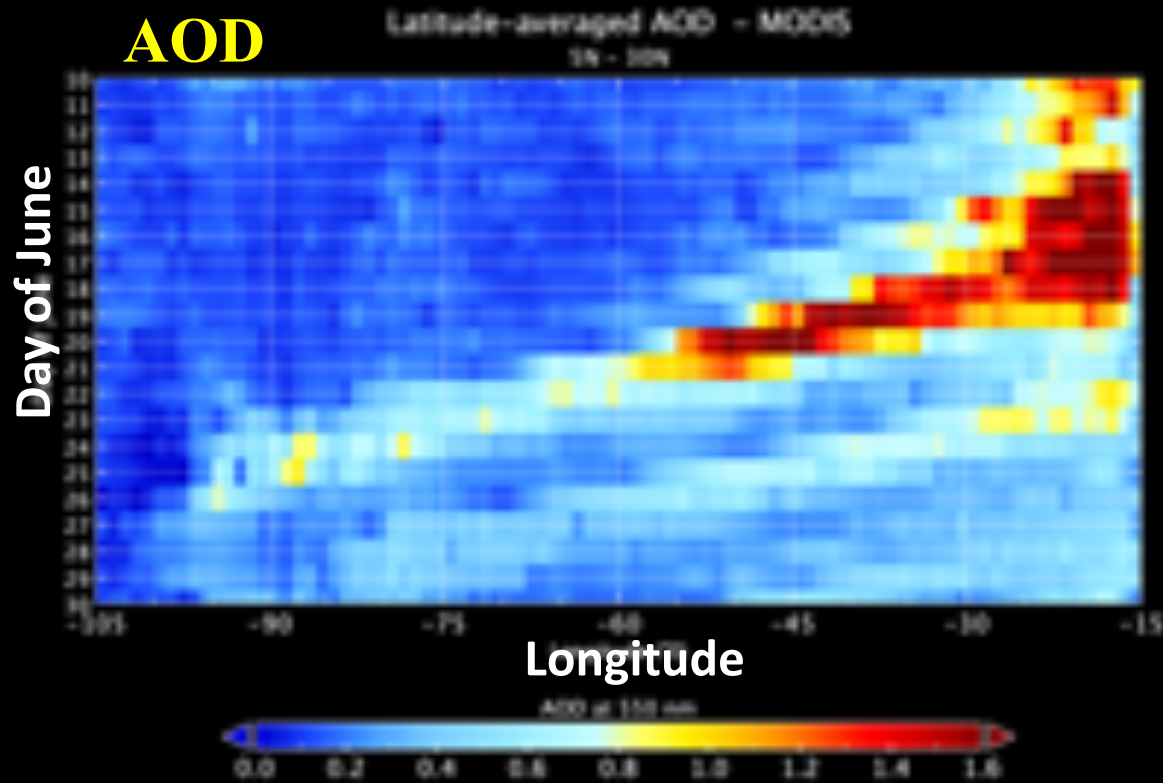


- Good agreement between MODIS & AERONET
- Two dust plumes are featured:
 - Primary “Gorilla”: AOD ~ 3.5
 - Secondary “Ordinary”: AOD ~ 1.0



Progression of trans-Atlantic dust plumes

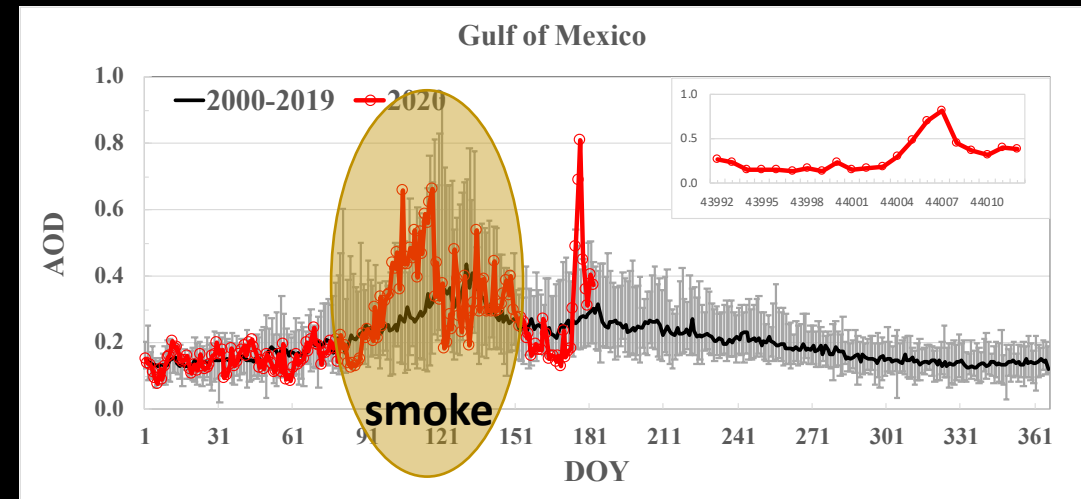
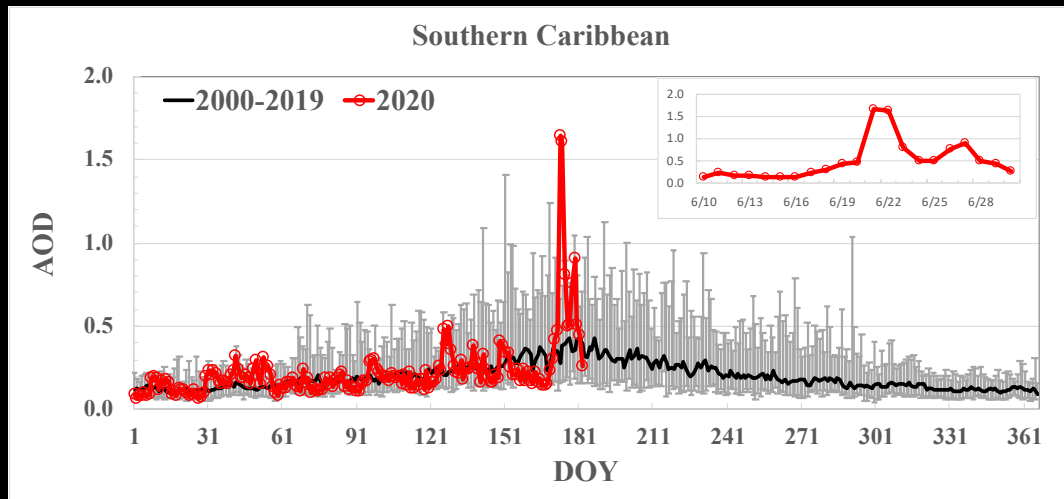
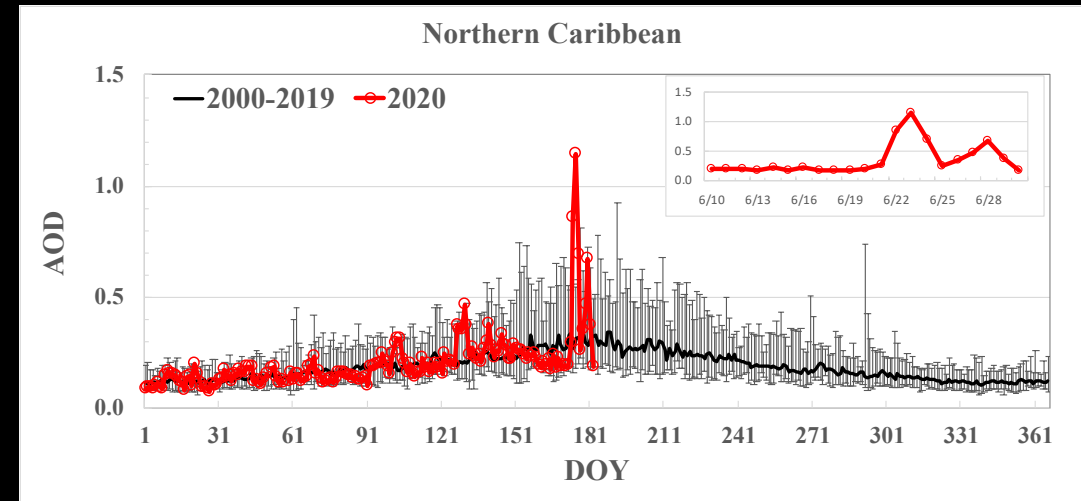
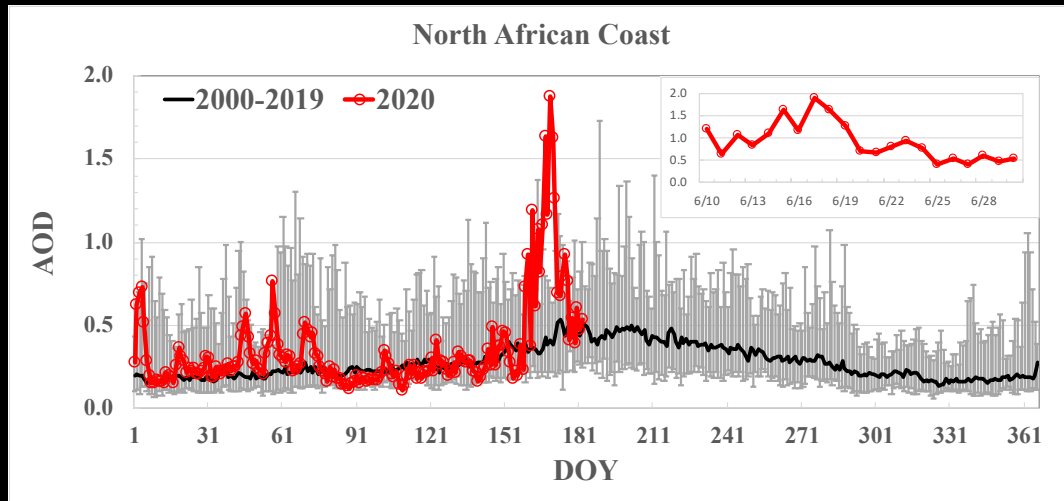
Time-Longitude Hovmöller Diagrams



Two dust plume tracks ~6 days apart are clearly seen in MODIS aerosol optical depth (*left*) and fine-mode fraction (*right*)

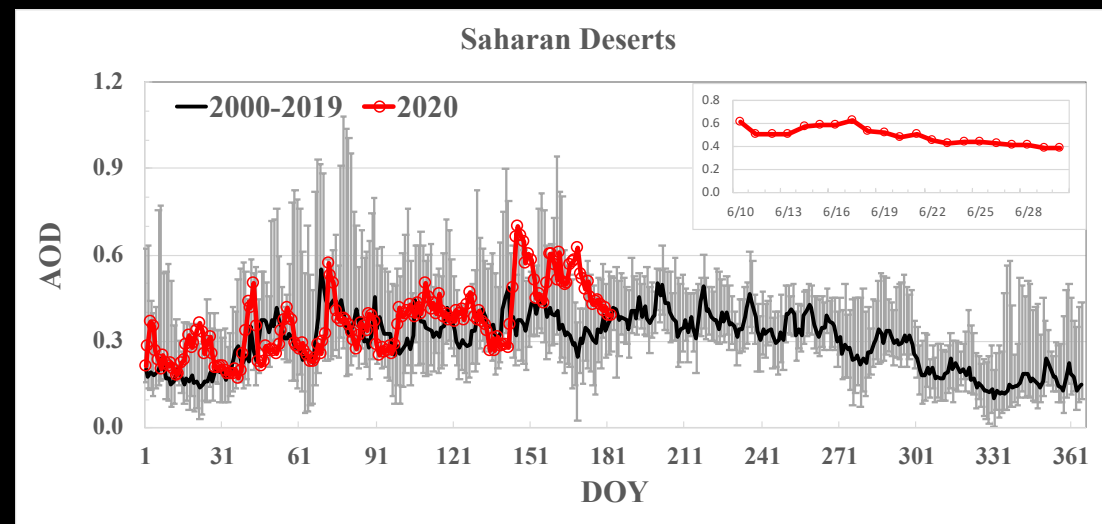


MODIS registered the event as *historic* over the last two decades



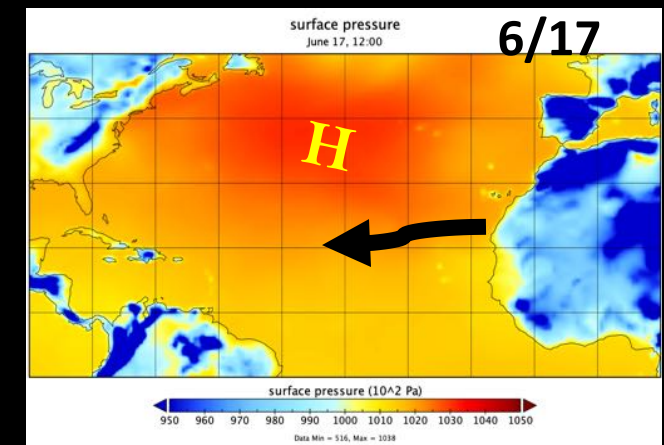
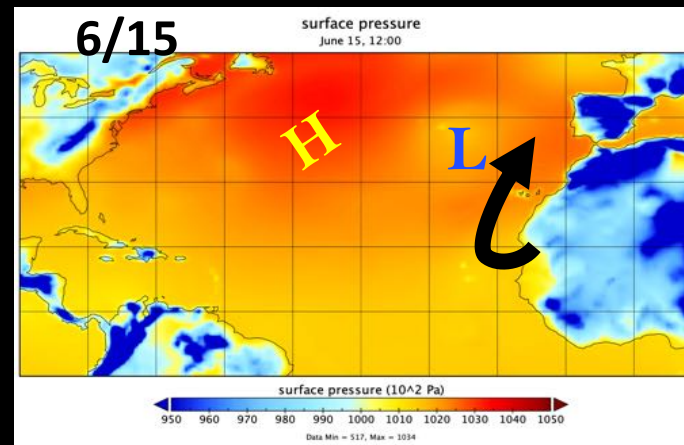
The historic dust intrusion into the Caribbean Basin was a result of dust accumulation spanning over several days in the coastal region followed by the rapid transport in the trade winds.

The accumulation was controlled by the anomalous northern drifting of the Bermuda-Azores High.



Emissions were large but not historic

MERRA-2 Surface Pressure



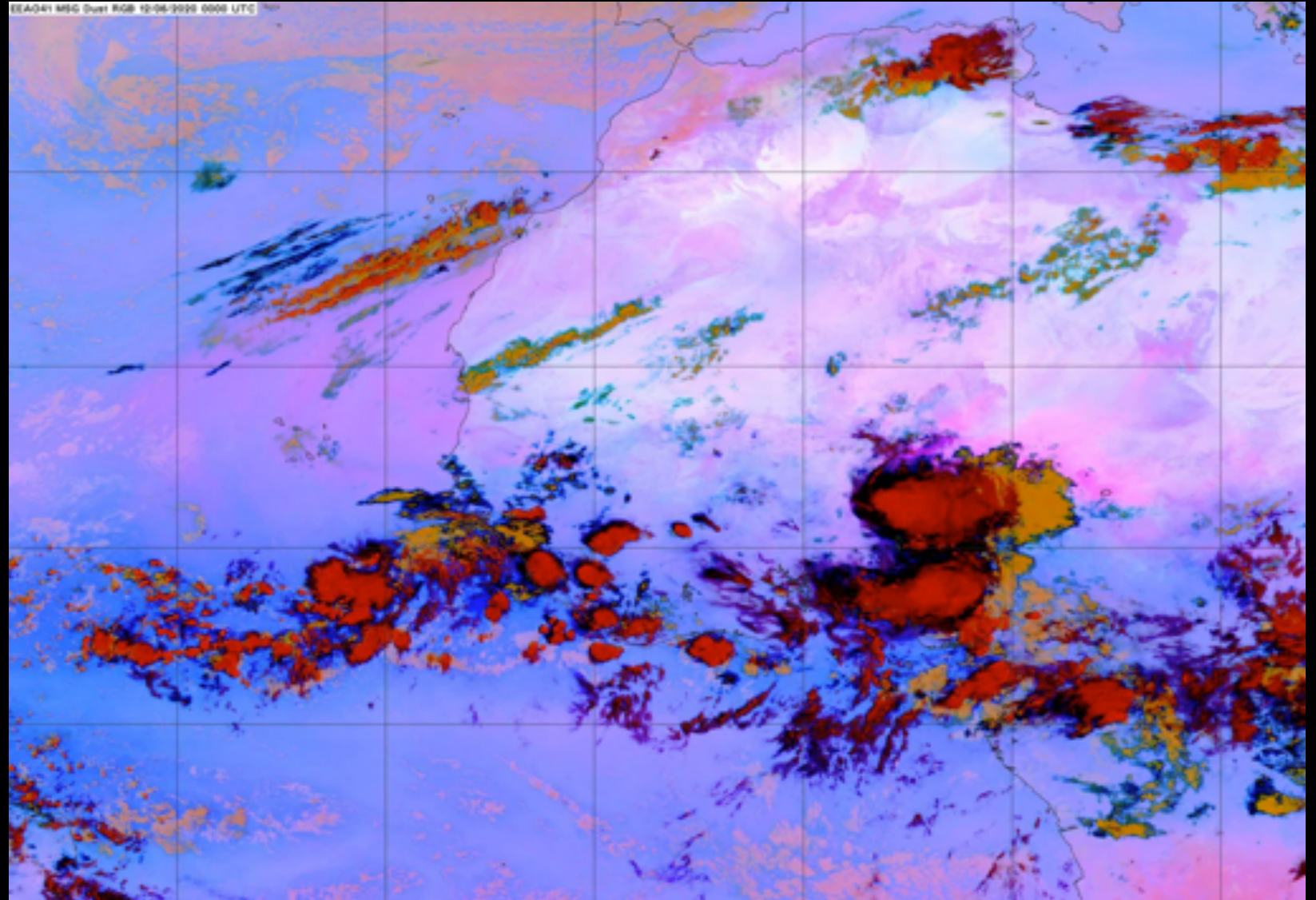
On June 14-16, **the Bermuda-Azores High** drifted northward and **a Low system** formed over Azores, leading to strong meridional winds and hence the dust accumulation in the coastal region.



SEVIRI Dust RGB images every 15 min (June 12-15)

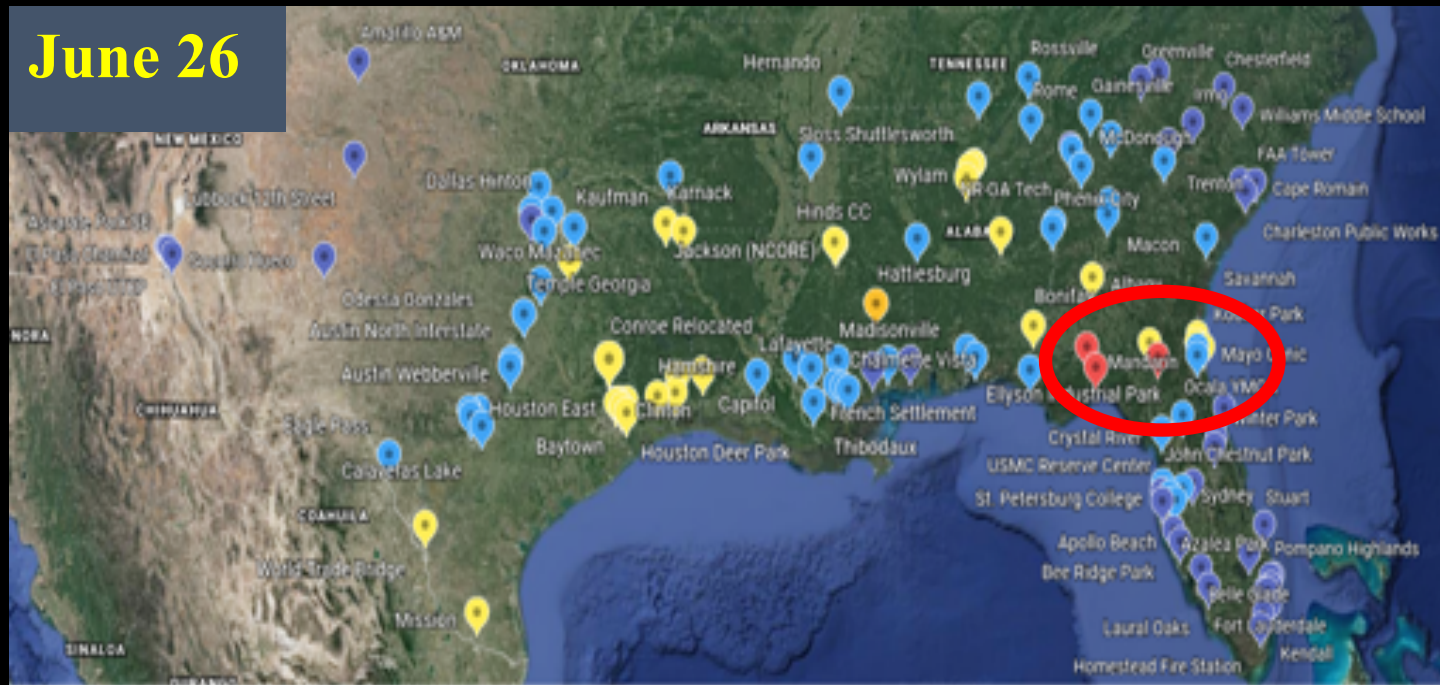
Dark red: Deep clouds
Orange: Middle clouds
Dull pink: Low cloud
Bright pink: DUST

Dust from large Haboobs and other sources in West Africa - Niger, Mali, Mauritania – was accumulated in the coastal area.

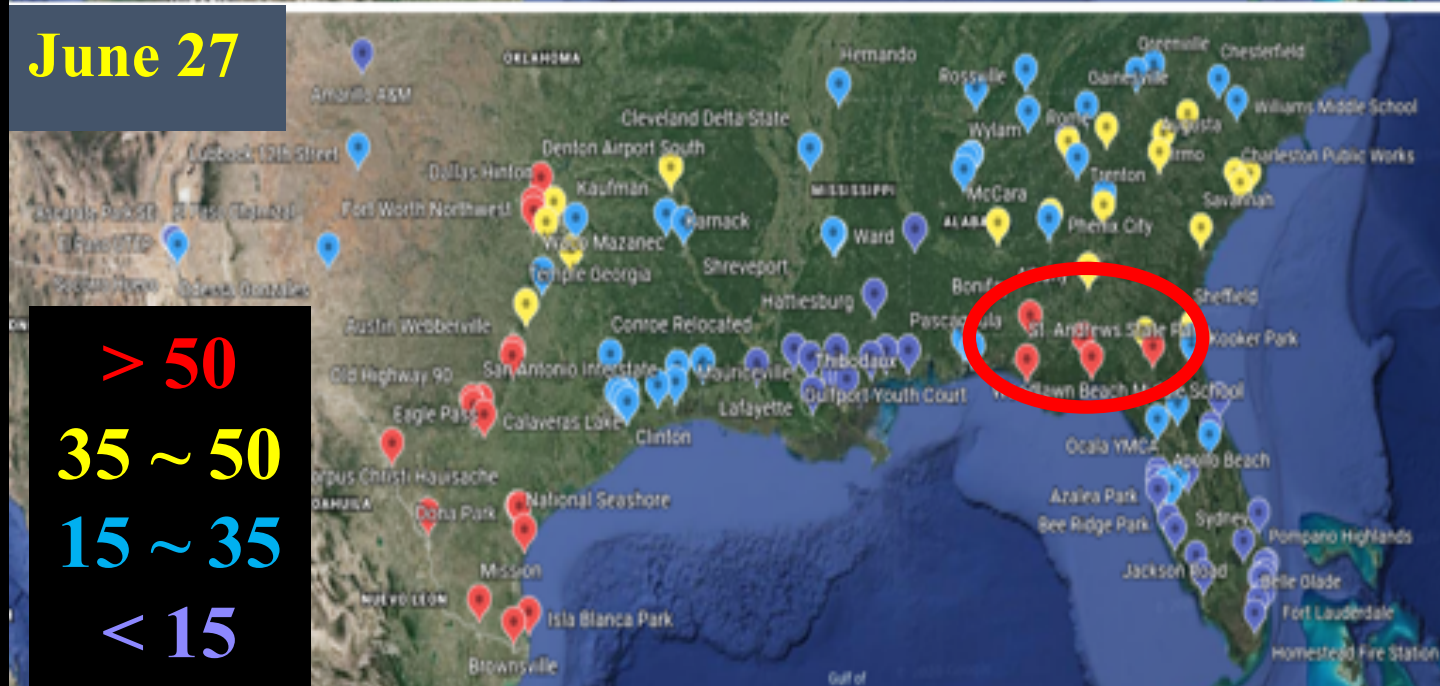


SEVIRI: Spinning Enhanced Visual and InfraRed Imager

June 26



June 27



The dust intrusion degraded air quality in southern U.S. on 6/26-27.

of sites in 9 southern U.S. states with daily $\text{PM}_{2.5}$ exceeding the U.S. AQ standard of $35 \mu\text{g}/\text{m}^3$

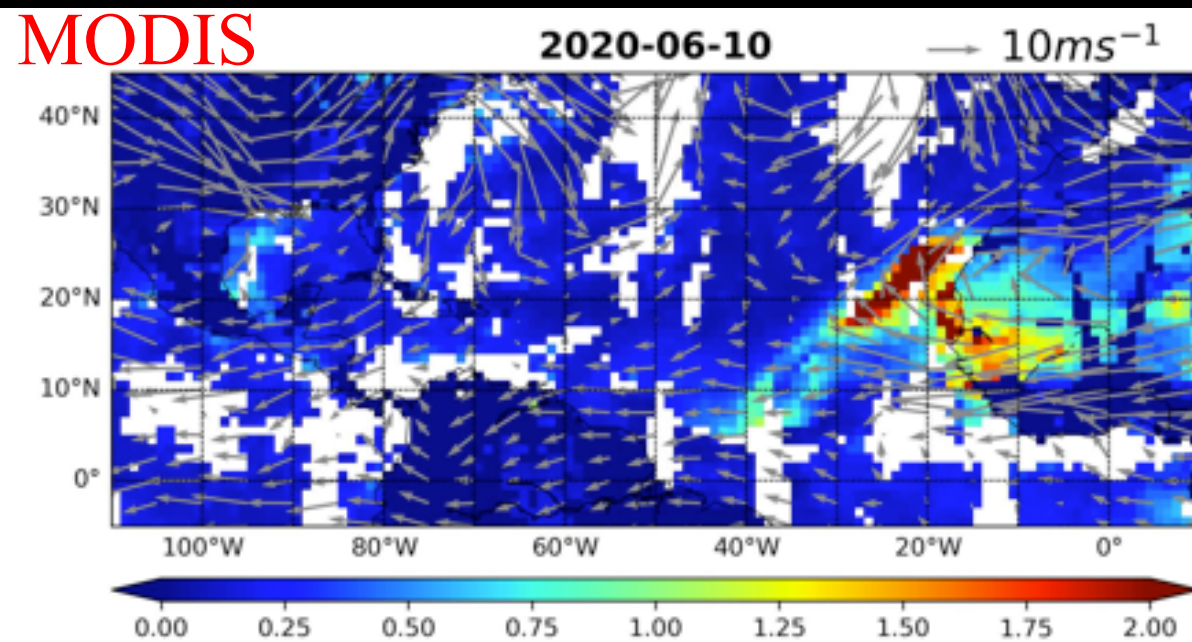
- 6/26 - 31 out of 158 (20%)
- 6/27 - 62 out of 150 (41%)



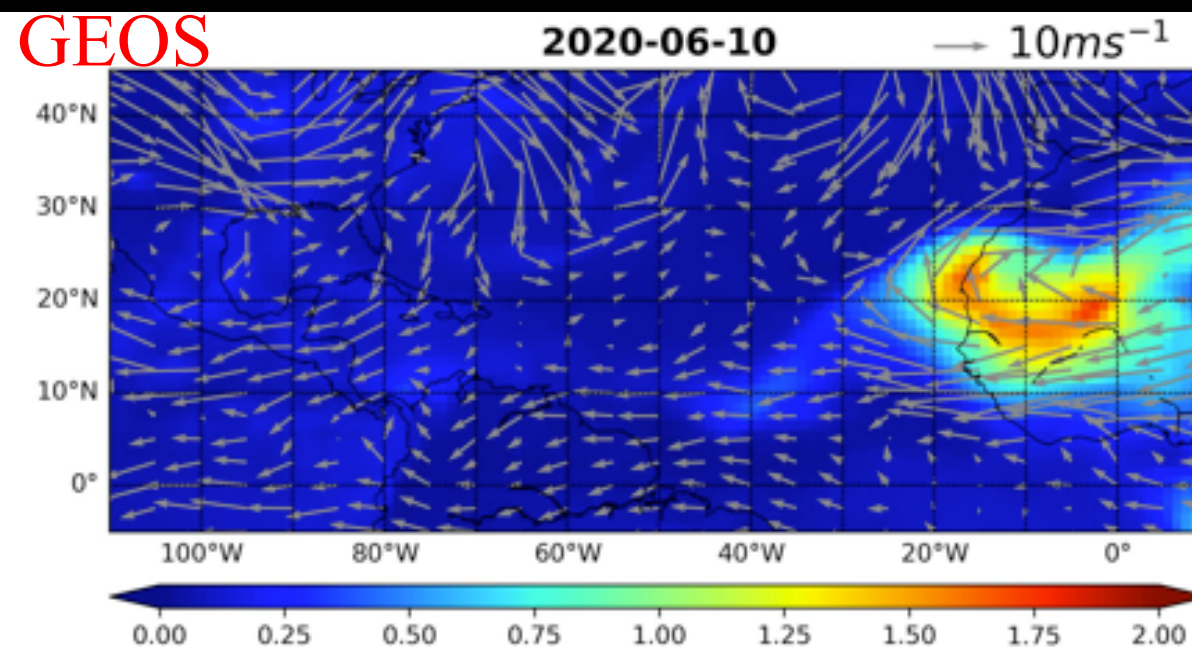
Does GEOS model capture the journey of trans-Atlantic dust plumes observed by MODIS?

- ❑ consistent path
- ❑ different magnitude

MODIS



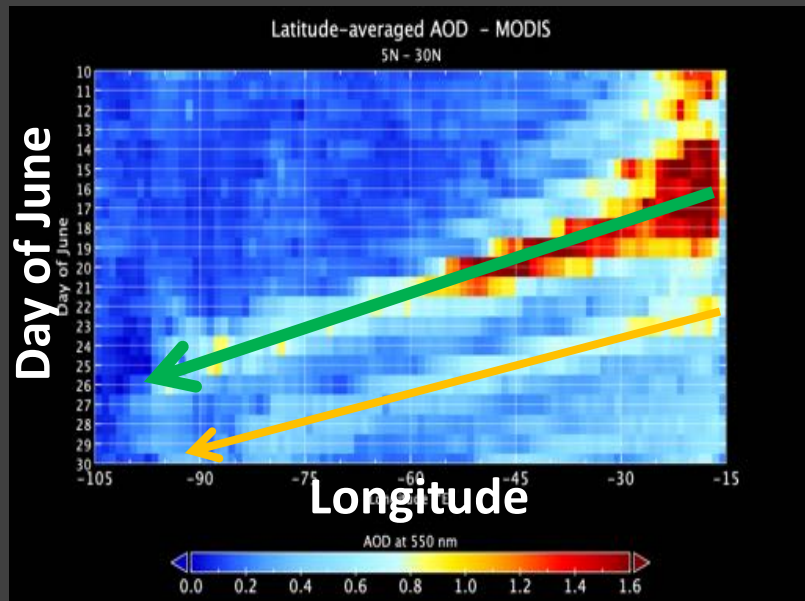
GEOS



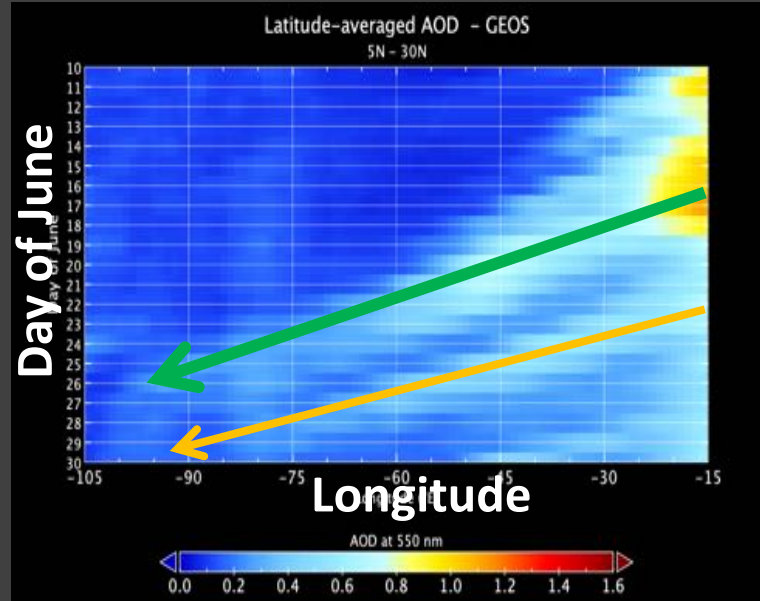
MODIS vs. GEOS

Longitude-Time Hovmöller Diagram

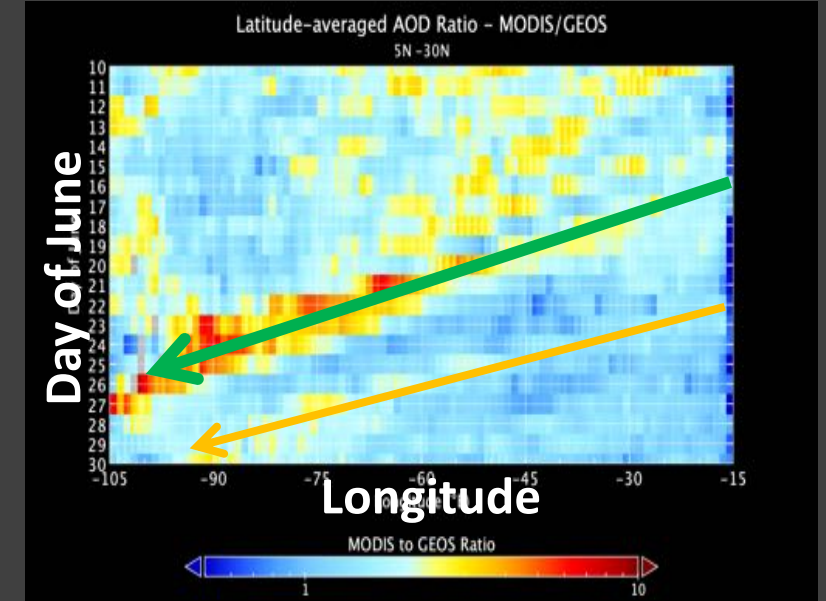
MODIS



GEOS



MODIS / GEOS

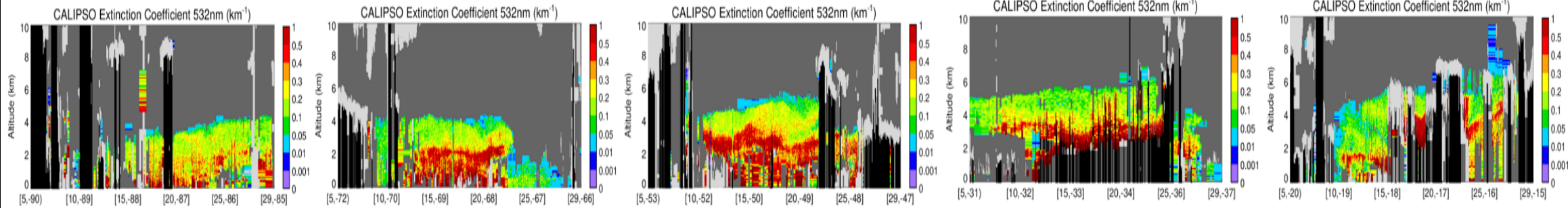


- ❑ GEOS underestimated MODIS AOD by factors of 2-5 for the "gorilla" plume.
- ❑ GEOS did better job for the "ordinary" plume (x2).

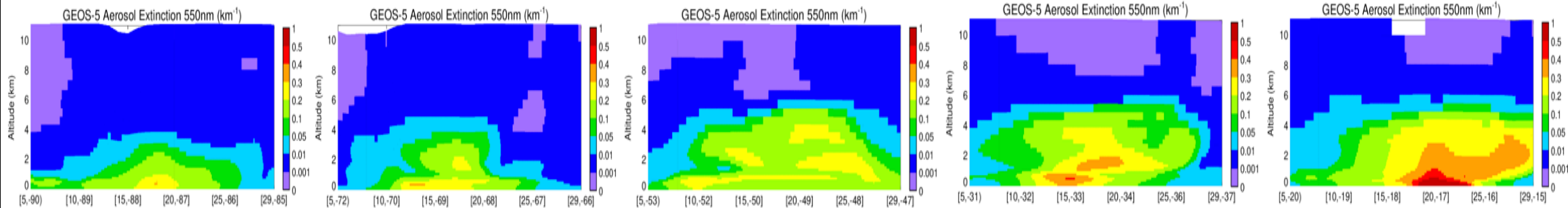


Vertical structure along the trans-Atlantic transit

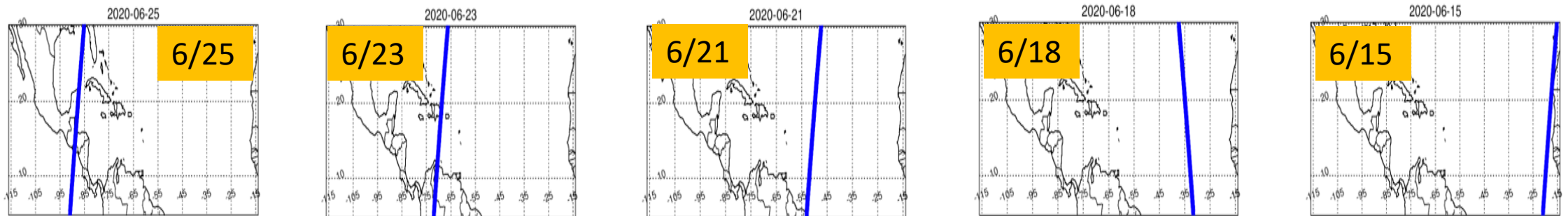
CALIOP



GEOS

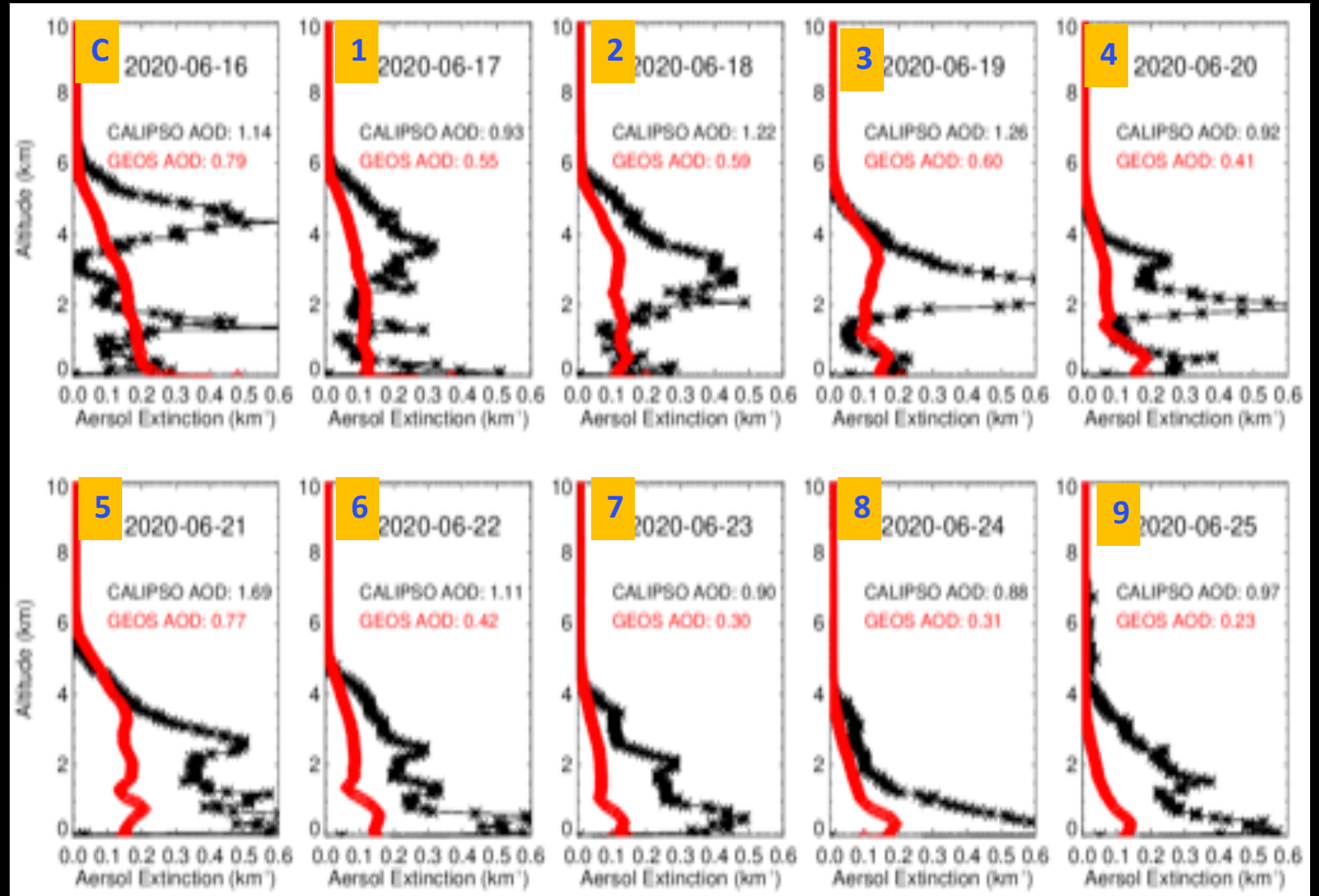
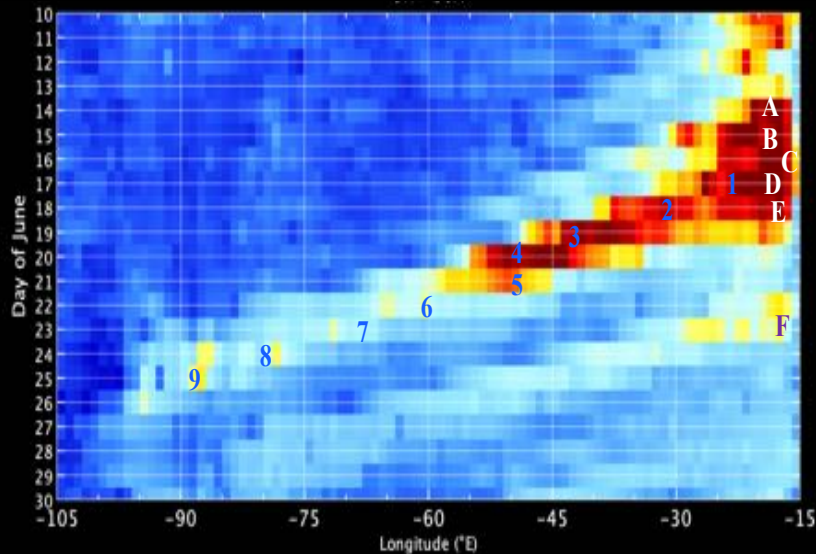


CALIOP
track



- ❑ GEOS simulate dust plume is generally lower than CALIOP observations.
- ❑ GEOS don't reproduce fine structures of the plume.
- ❑ GEOS substantially underestimates the aerosol extinction.

Average profiles

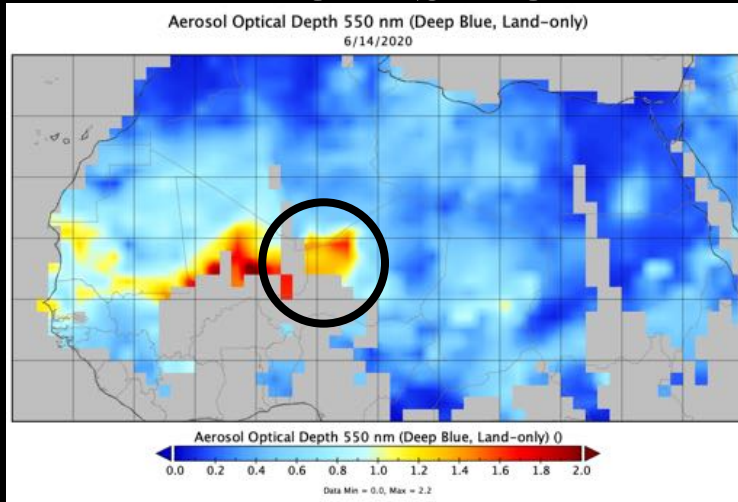


GEOS model outputs were sampled based on CALIOP observations of aerosol & clear-clean features (*cloud & attenuated excluded*)

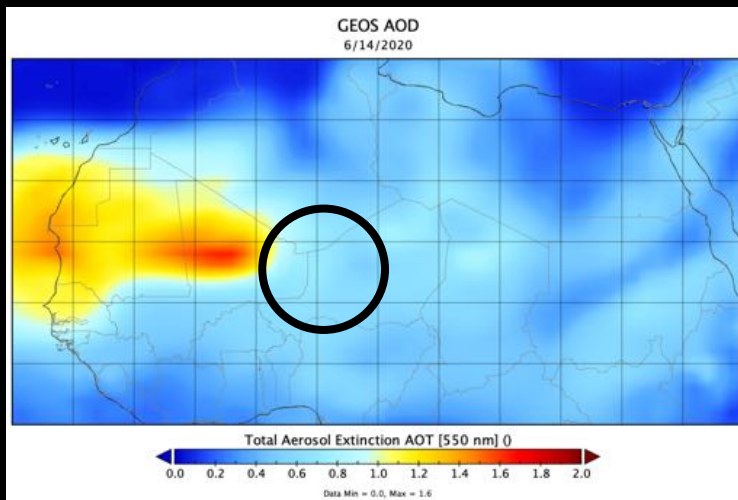


Saharan Deserts: Satellites vs. GEOS

MODIS AOD

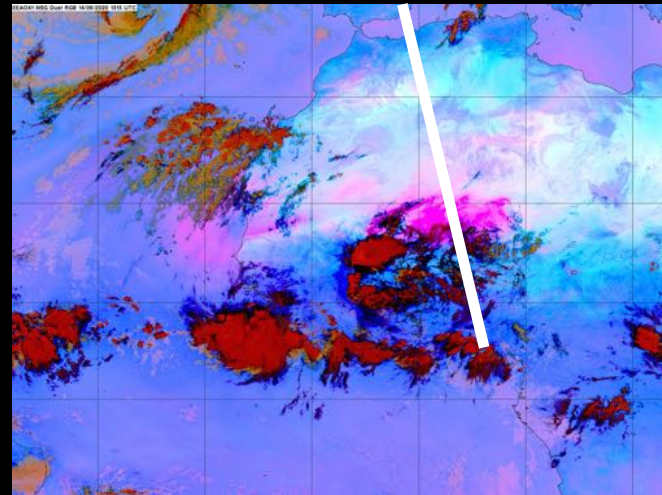


GEOS AOD

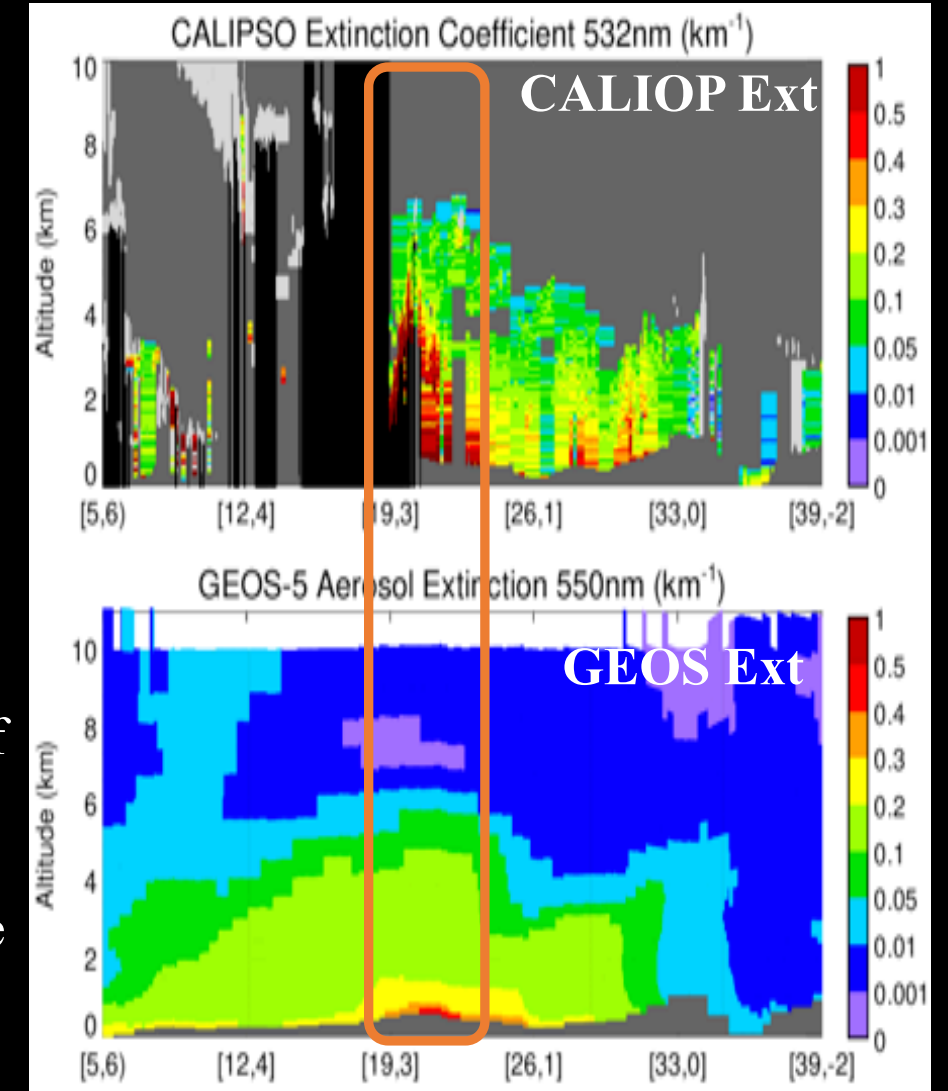


2020-06-14

SEVIRI



- GEOS underestimated AOD of Nigerian dust sources.
- GEOS didn't raise up adequate dust in haboob to high altitudes.



Take-home Messages

- MODIS observations registered this event as historic over the past two decades.
- Impacts on air quality were significant in the southern U.S.
- The historic dust intrusion was a result of dust accumulation spanning over several days in eastern Atlantic Ocean followed by a rapid trade-wind transport; and this was controlled by the anomalous drifting of the Bermuda-Azores High.
- GEOS captured dust plume track quite well.
- However, the model underestimated dust sources in Niger, didn't lift haboob dust high enough, and substantially underestimated magnitude of the dust intrusion.

